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ROSE DISEASES

THEIR CAUSES AND CONTROL

ROSE BUSHES, like all other plants, are susceptible to many diseases. Parasitic organisms may attack any portion of the plants—roots, stems, leaves, or blossoms. The presence of disease is revealed by the discoloration of the foliage, the failure of the buds to develop normally, or the death of portions of the stems. Therefore, persons who desire to grow roses, either for their beauty in the garden or for their commercial value, should have some knowledge of the causes of such diseases and the methods by which they may be prevented or controlled.

In this bulletin are described the most common fungous and bacterial diseases which may appear in the home garden, in the nursery, or in the greenhouse. The symptoms of each disease and the methods of control best adapted for general use are given.

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ROSE DISEASES: THEIR CAUSES AND CONTROL

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INTRODUCTION

THE CONDITION known as disease in roses, as well as in other plants, is usually the result of injurious action upon the plant tissues by certain agencies. These agencies may include not only parasitic organisms which live upon the plant tissues and derive from them the food necessary for their growth, but also such conditions of light, temperature, moisture, and soil as are unfavorable for growth and which therefore inhibit the normal development of the plant. For reasons not clearly understood, certain rose plants, particularly seedlings, fail to make a good start, even though careful attention is given to growth requirements and to protection from parasitic organisms and insects. Such cases are not considered in this bulletin. Insects[2] may cause abnormalities of plant tissue which result in a disturbance of the normal functions. For a consideration of the insect pests of the rose, the reader is referred to Farmers' Bulletin 1495.[3]

For the purpose of this bulletin, therefore, the diseases affecting the rose may be divided into two general groups: (1) Those due to conditions of growth, and (2) those due to parasitic organisms, such as fungi and bacteria.

CONDITIONS OF GROWTH

There are comparatively few localities in the United States in which some type of rose can not be grown out of doors. The tender

[1] In cooperation with the Department of Botany, Brown University, Providence, R. I.

[2] All inquiries as to treatment for insect pests should be directed to the Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

[3] WEIGEL, C. A., and MIDDLETON, W. INSECT ENEMIES OF THE FLOWER GARDEN. U. S. Dept. Agr. Farmers' Bul. 1495, 54 p., illus. 1926.

varieties, however, such as hybrid teas, are more restricted as to favorable localities. Plants grown successfully in one locality under certain conditions of climate and soil may fail completely under the different climatic and soil conditions of another locality. Therefore, if roses are to be grown out of doors, varieties should be chosen which are adapted to the climate and the soil.[4]

After a suitable variety has been selected and planted, it must be provided with the proper food in the form of fertilizers; it needs water, light, and air in the right proportions. An overabundant or an insufficient amount of these factors may result in a poor root system, tender or discolored foliage, buds which fail to mature, or imperfect, weak-stemmed blossoms. In the greenhouse all these factors may be more carefully controlled, but sudden changes may cause more serious injury than in the case of out-of-door plants, which are somewhat hardened to weather changes. For this reason special attention should be given in the greenhouse to the temperature and moisture of the air and soil, the application of fertilizers, the proper ventilation, and the lighting, in order to obtain the most favorable conditions for growth, particularly during forcing.

ORGANISMS CAUSING DISEASE

The second group of diseases is caused for the most part by fungous organisms. Because of the fact that they obtain their food from the tissues of the rose plant they are called parasites. They are simple forms of plant life and reproduce by means of small bodies known as spores. One disease described in this bulletin—crown gall—is caused by a bacterium, a very simple form of plant life which, like the fungi, lives as a parasite upon the rose. It belongs to that group of organisms which cause many diseases of man.

The diseases described in this bulletin are those which appear most commonly in the home garden, in the nursery, or in the greenhouse. The methods of control recommended for each disease are those which have proved to be best adapted for general use.[5]

LEAF DISEASES

POWDERY MILDEW[6]

Powdery mildew is one of the most common diseases of roses and is very rarely absent from any rose garden or greenhouse during the growing season. Nearly all types of roses are susceptible, including wild roses, hybrid perpetuals, hybrid teas, and climbing roses, particularly the Crimson Rambler and Dorothy Perkins.

SYMPTOMS

Very early in the season, in fact soon after the leaves begin to develop, there may appear on the leaves a powdery whitish coating

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[4] Information on the selection of varieties and methods of cultivation and pruning is given in the following publication: MULFORD, F. L. ROSES FOR THE HOME. U. S. Dept. Agr. Farmers' Bul. 750, 39 p., illus. 1921. (Revised ed.)

[5] Information on the use of sprays other than those mentioned in this bulletin may be obtained from the Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

[6] Caused by species of Sphaerotheca.

which is the characteristic symptom of the disease (fig. 1). This coating is made up of chains of small colorless spores, by means of which the fungus reproduces. If warm, muggy weather occurs in the late spring or early summer, the development of the disease may be extremely rapid. In the case of a severe attack the growth may become stunted, the leaves may curl, become dried, and drop off, and

FIG. 1.—Rose leaves infected with powdery mildew

unopened buds (fig. 2), young stems, and thorns may be entirely overgrown with the powdery coating.

It is only in very rare cases that the death of the plant results from an infection by mildew. Usually the presence of the fungus hinders the normal development of the plant and causes a disfiguring of the foliage. These, however, are sufficient reasons for attempting to control the trouble. Since the method of treatment for the powdery mildew is almost identical with that for black spot, the discussion of treatment for the two diseases is combined (p. 4).

BLACK SPOT[7]

Black spot, occurring on both outdoor and indoor roses, is almost as common as the powdery mildew. Although many varieties of tea roses show some degree of resistance to it, others which have more tender foliage, such as the Ophelia, are extremely susceptible.

SYMPTOMS

The ordinary name of the disease is derived from the irregular black spots (fig. 3) which are the characteristic symptoms. These spots first appear as small, isolated areas scattered over the upper surface of the leaflets. As the fungus develops, these areas increase in size and may grow together until almost the entire leaflet is affected. When this condition occurs the remaining portions of the leaflet turn yellow and it falls off. As infection spreads throughout the plant, defoliation takes place. A second crop of leaves is then developed in late summer, and this new growth does not become mature before cold weather; therefore the plant does not receive from these leaves sufficient food to carry it through the winter in a normal healthy condition, and a weakening of the plant results.

FIG. 2.—Powdery mildew on buds of a rambler rose

The manner in which black spot develops differs from that in which mildew develops, in that the organism producing black spot lives within the leaf tissue, whereas the organism producing powdery mildew lives almost entirely upon the surface of the leaf.

CONTROL OF MILDEW AND BLACK SPOT OUT OF DOORS

In the case of out-of-door roses it has been found that measures which are successful in controlling mildew are also effective against

[7] Caused by *Diplocarpon rosae* Wolf.

black spot. Such measures include improvement of growth conditions, sanitation, treatment with fungicides, and the growing of resistant varieties.

IMPROVEMENT OF GROWTH CONDITIONS

The germination of a fungous spore can take place only in the presence of moisture. Therefore a humid atmosphere or any other

FIG. 3.—Black spot on rose leaves

condition in the garden which causes an accumulation of moisture on the plants is especially favorable for spore germination and the resulting infection. Such conditions may occur as a result of too-close planting, where shading and lack of ventilation prevent the proper evaporation of excess moisture from the leaf surfaces. Moreover, the planting of climbing roses near buildings has the same effect, since a free circulation of air is impossible.

SANITATION

Since the causal organisms can overwinter on dead parts of the plants, sanitation methods should be employed. These consist of the collection of diseased leaves which have fallen to the ground and the immediate destruction by burning of all such refuse.

FUNGICIDES

The fungicide which has been found most practical, especially in home gardens, is a dust mixture consisting of 9 parts powdered sulphur to 1 part dry arsenate of lead. The sulphur which is used in this mixture and which gives the most desirable results is not that commonly known as flowers of sulphur, but is a specially prepared, finely ground dusting sulphur. The flowers of sulphur is not as efficient as the dusting sulphur. This dusting mixture is inexpensive, is easily applied, and does not discolor the foliage to any appreciable extent.

The arsenate of lead is efficient as an insecticide in controlling leaf-chewing insects. However, its particular value in this mixture lies in the fact that it tends to prevent the lumping of the sulphur and to increase the adhesive qualities of the mixture. Thus its use results in a more even distribution and lessens the loss by rains. If nicotine sulphate is added to the mixture,[8] many sucking insects also may be controlled.

It is advisable that the dusting be done when the air is comparatively calm and the leaves dry, so that an even distribution of the dust may be obtained. The mixture is applied by means of a dust gun, which may be procured at seed stores.

The first application of the dust should be made as soon as the leaves begin to develop. It is not advisable to wait until the disease appears, particularly in the case of black spot, since the principal object of the dust mixture is to prevent infection. Repeated applications at intervals of 10 days or two weeks should be made until late summer, not only to make up for the slight loss of the powder from the leaf surfaces due to rain or other causes, but also to provide protection for the new growth. It must be remembered that one application will not entirely control the disease.

Sprays, such as Bordeaux mixture or ammoniacal copper carbonate, sold at most seed stores, are effective in controlling the diseases. The use of the Bordeaux mixture, however, results in a discoloration of the foliage which is very objectionable to many rose growers. The ammoniacal copper carbonate does not have this disadvantage, but because of the difficulty of preparing and applying a spray of any kind, the dust mixture is preferred by many rose growers.

RESISTANT VARIETIES

Different varieties of roses vary greatly in their susceptibility to mildew and black spot. Varieties which have proved resistant in one locality under certain conditions of growth may be more sus-

[8] Directions for preparing and applying this dust mixture for use as an insecticide are given in the following publication: WEIGEL, C. A., and MIDDLETON, W. INSECT ENEMIES OF THE FLOWER GARDEN. U. S. Dept. Agr. Farmers' Bul. 1495, 54 p., illus. 1926. (See pp. 2–4.)

ceptible in another locality or under changed conditions. Therefore, rose growers who wish to control disease by growing resistant varieties should observe carefully the behavior of the plants under the conditions present in their own locality.

CONTROL OF MILDEW AND BLACK SPOT IN THE GREENHOUSE

In the greenhouse careful attention should be given to the protection of the plants from sudden changes of temperature and from drafts, so that their normal growth will not be hindered in any manner. Overwatering, especially in dark winter weather, should be avoided. Too-close planting not only prevents proper ventilation but also allows infected plants to come into contact with healthy ones. In this way a spread of these diseases may easily occur. Affected leaves which have fallen from the plants should be collected and burned immediately, in order to kill the fungi which might cause new infections.

A common method of controlling these diseases in the greenhouse is to vaporize sulphur. The flowers of sulphur is put in a vessel having a small opening and is evaporated by a steady heat, such as that furnished by an oil stove, until a heavy vapor fills the house. This vapor condenses on the leaves and acts as a fungicide. Great care must be taken to prevent the ignition of the sulphur, since the vapor from burning sulphur seriously injures the foliage. It is advisable, therefore, to place the vessel containing the sulphur in a larger pan of sand over the oil stove. Another method consists of painting the heating pipes during the winter with a smooth paste composed of equal parts of sulphur and lime mixed with water.

RUST[9]

The rust of roses, although not so common as either powdery mildew or black spot, is very destructive wherever it is found. Both wild and cultivated varieties are susceptible, but so far as known it does not appear on greenhouse plants.

SYMPTOMS

The most characteristic symptom of rust is the appearance, on any green portions, of small orange-colored pustules, from the color of which the disease gets its name. In early spring there may appear on either surface of the leaves very small orange or yellow masses, usually so inconspicuous as entirely to escape detection (fig. 4). Later, the larger and more conspicuous spots occur on the lower surface, and this condition exists throughout the summer. In late summer or early fall the character of the spots changes and black pustules appear, frequently in the same affected areas. These pustules overwinter within the leaf tissue after the leaves have fallen, and from them are produced the spores which cause the spring infection. Other green parts of the plant, such as young stems, may also be seriously infected. Distortion of these diseased portions sometimes results.

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[9] Caused by species of Phragmidium.

CONTROL

An important step in the control of rust is to destroy the infected portions so as to prevent the spread of the infection. Therefore, whenever possible, diseased leaves should be collected and burned at once. As a supplementary measure a spray, such as Bordeaux mixture, may be used. If a small garden or only a few bushes are to be treated, the prepared Bordeaux mixture as sold at seed stores, with directions for using, will be found sufficiently effective.[10] If a home-prepared mixture is desired, it may be made according to the following formula, which is an adaptation of the spray known as 4–4–50 Bordeaux:

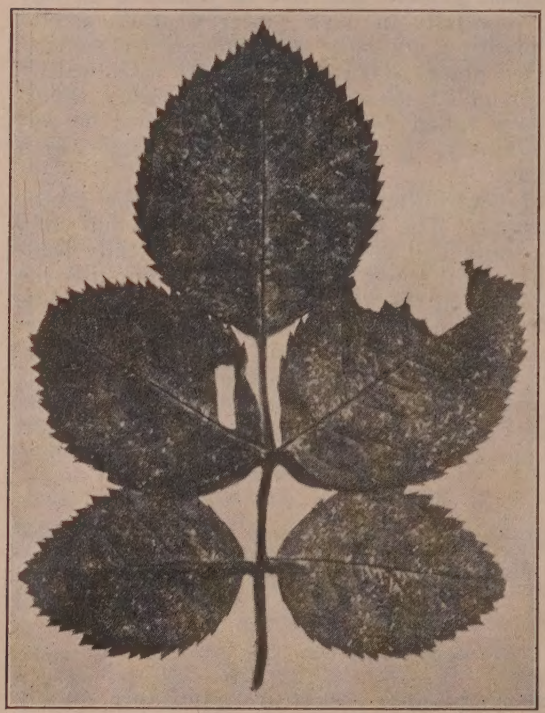

FIG. 4.—Minute yellow spots on the upper side of a leaf, scarcely visible to the naked eye, indicate the presence of rust

Copper sulphate (bluestone)---- 2½ ounces.
Lime (unslaked) 2½ ounces.
Water------- 2 gallons.

The copper sulphate is thoroughly dissolved in 1 gallon of water. The lime is slowly slaked with a little water, making a smooth paste; enough water is then added to make a gallon of milk-of-lime solution. When the spray is to be used, the two solutions are gradually poured at the same time into a third vessel. While mixing, the solution should be thoroughly stirred. It should then be strained and used immediately.[11] Only copper, wooden, or earthenware containers should be used.

Applications of this spray may be made at intervals of two weeks during the growing season. Since the fungus overwinters on the fallen leaves, it is advisable to spray the plants in the late fall or early winter after they have become dormant, and again in the spring before active growth commences. For the dormant plants the

[10] For additional information concerning the Bordeaux mixtures sold by seed stores, see the following publication: WALLACE, E., and EVANS, L. H. COMMERCIAL BORDEAUX MIXTURES. HOW TO CALCULATE THEIR VALUES. U. S. Dept. Agr. Farmers' Bul. 994, 11 p., illus. 1918.

[11] If a larger quantity than 2 gallons is required, stock solutions may be prepared according to the formula given in the following bulletin: ROBERTS, J. W., and PIERCE, L. APPLE SCAB. U. S. Dept. Agr. Farmers' Bul. 1478, 12 p., illus. 1926. (See p. 10.)

quantity of water used in the spray may be decreased to 1½ gallons. The chief disadvantage of this Bordeaux mixture is that it will stain the foliage. If the rose grower objects to this staining, the Bordeaux mixture may be used only when the plants are in a dormant condition.

When the disease first appears and during the early part of the growing season the sulphur-arsenate of lead dust may be used to advantage to prevent further infection. If the disease becomes particularly severe, however, it is almost impossible to control it. The immediate removal and destruction of all affected bushes as soon as the disease appears is then the only method of preventing the spread of the trouble.

FIG. 5.—Leaf spots as they appear on the upper side of a leaf

LEAF SPOT

Leaf spot is rarely very serious. It may occur on any variety of hybrid roses in the nursery, however, and if conditions are favorable for its development may cause some injury to the plants through defoliation.

SYMPTOMS

Leaf spots may be caused by a number of different fungi,[12] all of which produce the same symptoms. The spots appear first as small yellowish green dots. These increase in size, become brown, and usually have a purplish border (fig. 5). In some cases the diseased tissue falls out, giving the leaves a shot-hole appearance. If this diseased tissue remains as a part of the leaf, the affected areas continue to enlarge, and the whole leaf becomes yellow and falls off. The organism producing the disease continues to live on the dead tissues and bears another kind of spore which causes the spring infection.

CONTROL

As in the case of the leaf diseases already described, all affected leaves should be collected and destroyed by burning. The sulphur-arsenate of lead dust mixture recommended for mildew and black spot should be used during the growing season.

[12] Leaf spots may be caused by species of Cercospora, Phyllosticta, Septoria, and other genera.

FIG. 6.—Canker which started from infection of the wound at the lower end of the prickle. The canker extends above the wound to a point a little above the prickle and to about an equal distance below the wound. It is characterized by the smoother bark above and below the wound

FIG. 7.—Old canker which started at the wound left by the removal of a prickle. The diseased area is slightly sunken below the surface level of the rest of the stem and is bounded by a raised margin

STEM DISEASES

STEM CANKER[13]

Aside from the diseases affecting the leaves of the rose plant, one of the most important injuries which commonly occurs is the formation of cankers on the stems. Although all canker diseases are characterized by stem cankers, the diseases have been variously named by the investigators who have studied the fungi causing them. Attempts have been made to designate by a distinctive name a disease caused by a particular fungus. Therefore, although the term "stem canker" could be applied equally well to any of the diseases described in the following pages, its use is commonly restricted to the disease caused by this particular fungus.

Any portion of the stem may be affected. Wounds produced in the bark from any cause whatever afford a means of entrance for fungous spores which may produce infection (figs. 6 and 7). Nearly all varieties of out-of-door roses suffer from the trouble. Raspberries are also susceptible to this disease.

FIG. 8.—Side view of a canker on a dead stem, showing the raised margin defining the diseased area

SYMPTOMS

The first symptoms of the disease are small pale-yellow or reddish spots on the bark. These gradually increase in size, and several spots may grow together, resulting in a large infected area. The wood tissue in these areas becomes dried and the bark cracked, so that a wound or canker is formed (fig. 8). This may increase in size until the entire stem is girdled and the part above the wound becomes wilted and dies.

When hybrid tea plants are uncovered in the spring, very frequently it is found that the tips of the stems which had been pruned

[13] Caused by *Coniothyrium fuckelii* Sacc.

the preceding year are brown and dead. A careful examination shows the presence of a canker encircling the stem and extending down it for some distance. The lower part of an infected stem may appear healthy for some time, but if the canker is allowed to remain it slowly spreads down the stem and eventually the lower branches become infected.

CONTROL

One of the most important measures in the control of the disease is the pruning out of all affected portions and their immediate destruction by burning. So far as known, the disease does not directly attack either the leaves or blossoms, but it weakens the plants so that the production of healthy foliage and flowers is considerably hindered. Sprays of any kind are of little or no value. Special attention should be given to pruning and to the protection of the resulting cut surfaces, since it is principally through this exposed wood that infection takes place. In the spring, or at least just before the growing season begins, the plants should be carefully examined for the presence of cankers, and all parts thus affected should be pruned out, the cuts being made well back of the diseased tissue into the healthy wood. All the cut surfaces where the wood is exposed may be covered with a coating of paint or shellac. Any wounds appearing on any portion of the stems should be similarly treated. Since spores of the fungus may easily be carried from one bush to another on the pruning shears, it is advisable in all cases where cankers are being pruned out to disinfect the shears each time after using them on a diseased plant. Such disinfection may be done by dipping the shears in a solution made in the proportion of 1 ounce of commercial formalin (40 per cent formaldehyde) to 2 gallons of water.

BRAND CANKER [14]

A disease which has only recently been found to occur in the United States is that known as brand canker. It has been reported from only two States—Minnesota and New York.

SYMPTOMS

The cankers first appear on the bark as small, pale-brown, oval spots surrounded by a purple border. Infection seems to take place through the wounds left by the removal of prickles or through dormant buds on the stems (fig. 9). The spots increase in size and in some cases they completely surround the stem. The diseased bark becomes dried and cracked and the whole area is slightly sunken below the level of the healthy tissue. In many cases the woody tissue of the stem is killed only in the area defined by the purple border. The portions immediately adjoining remain green and healthy until invaded by the fungus. For this reason the cankers stand out in sharp contrast. Any portions of the canes from the ground level to the tip may be attacked and frequently the lesions on one cane are so numerous that they coalesce. The tips of long canes of ramblers may be killed back for several feet and give the general appearance

[14] Caused by *Coniothyrium wernsdorffiae* Laubert.

of having been winterkilled. At the base of these killed portions, however, may be found one or more cankers girdling the stem.

CONTROL

All affected canes should be pruned out by cutting them back to the ground level and should be destroyed by burning. This means the complete removal of all diseased 1 and 2 year old growth. The new growth of the present season should then be sprayed with 4–4–50 Bordeaux mixture (p. 8), repeated applications at intervals of two weeks being made throughout the summer.

BROWN CANKER [15]

Brown canker, although rather prevalent through the eastern and southeastern United States, has only recently begun to be recognized as one of the important fungous diseases of the rose. The disease seems to be particularly prevalent on hybrid tea roses. There is a possibility that it is present in many nurseries and rose gardens, even in propagating beds, but that because of a lack of knowledge concerning the symptoms and nature of the disease it is entirely overlooked.

SYMPTOMS

The brown cankers may occur on any portion of the stem (fig. 10) and are sometimes separated from the healthy tissue by a reddish purple border very similar to that of brand canker. They differ from the cankers already described (p. 11) principally in the shade of brown. It is this slight differentiation that causes the difficulty in distinguishing between the different types of cankers. It has recently been found that the fungus is capable of affecting not only the stems but also the leaves and blossoms. Because of its tendency to disfigure the blossoms as well as weaken the stems, it is apparently one of the most important rose diseases from an economic standpoint.

FIG. 9.—Brand canker. Spores are produced in the small black pustules on the canker. The dark margin defines the upper limits of canker. Infection probably occurred through the bud shown near the center of the canker

CONTROL

The control of this disease is in general the same as that already described for other types of cankers. The affected portions of the

[15] Caused by *Diaporthe umbrina* Jenkins.

stems should be pruned out and destroyed by burning. Since the foliage and blossoms may be injured by the fungus and since small cankers may escape detection, the use of a spray is advisable. The 4–4–50 Bordeaux mixture previously described (p. 8) is known to be efficient in controlling infection. However, if the discoloration of the foliage resulting from this spray is considered a disadvantage, a spray solution of ammoniacal copper carbonate may be substituted. This spray, with directions for using it, may be purchased at seed stores or may be made in small quantities according to the following formula:

Copper carbonate	¼ ounce.
Strong ammonia water (26° Baumé)	About ½ gill (4 tablespoons).
Water	2 gallons.

Because of the strength of the fumes, the ammonia should not be handled in a closed room and should be diluted with water to several times its volume. The copper carbonate is moistened with sufficient water to make a paste. To this the diluted ammonia is added slowly, with constant stirring, until the carbonate is entirely dissolved. Water is then added to increase the volume to 2 gallons. Because of the difficulty of working with the strong ammonia, this spray is commonly recommended only when other sprays are unsuitable for any reason. The ammoniacal copper-carbonate solution does not stain the foliage.

It is exceedingly difficult to control infection of the blossoms, since no rose grower would care to drench his blossoms with a fungicidal solution so thoroughly as to cover all parts of the petals. Infected blossoms should be cut off and burned, but aside from that it is advisable to limit one's efforts at control to the foliage and stems. In the case of severe attacks the destruction of all affected plants may be the only method of control.

CANE BLIGHT[16]

One of the less-prevalent diseases on out-of-door roses is cane blight, which is identical with a disease of the same name occurring on currants. Up to the present time it has been reported from only a few localities. It may, however, be more common than is known, but since its symptoms are identical with those produced by other less injurious causes it may be entirely overlooked.

SYMPTOMS

Usually the first indication of the presence of the disease is the wilting of the foliage. The leaves gradually become brown and dead, but remain attached for some time. This condition might easily be mistaken for injury from late frosts. However, a careful examination of the diseased stems will reveal the presence of cankers of various sizes. Sometimes the entire stem is killed from the ground level to its tip. In other cases the cankers are scattered over the stem, killing only the leaves within the affected area. Since these symptoms resemble very closely those of other canker diseases on the rose, an identification of the causal fungus is usually necessary in order to determine the particular disease.

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[16] Caused by *Botryosphaeria ribis chromogena* Grossenbacher and Duggar.

CONTROL

The treatment for the control of the disease should consist of the pruning out and burning of all affected portions. Because of the difficulty of thoroughly pruning out diseased areas at the ground level very frequently portions of cankers may be left. Special care should, therefore, be taken to remove all cankers. The bushes may then be sprayed with Bordeaux mixture (p. 8) or ammoniacal copper carbonate (p. 14).

Since the same disease is known to occur on currant bushes and also on horse-chestnut trees, roses should not be planted in the vicinity of either of these hosts if they are known to be affected.

CROWN CANKER[17]

Another type of canker (crown canker) affecting rose plants is caused by a fungus which is capable of living for some time within the soil, and which, so far as known, attacks only greenhouse roses. It is found particularly in the eastern and northern United States.

Since infection usually occurs as a result of the growth of the

FIG. 10.—Brown canker. This canker was infected at three points. The portion of the stem above the uppermost canker was killed, but the leafy shoot below the lowest canker was not affected

[17] Caused by *Cylindrocladium scoparium* Morg.

fungus in the soil, the portion of the stem near the surface of the ground is most commonly affected. Any part of the stem, however, is susceptible, particularly if wounds are present. The fungus also seems to be capable of penetrating the bark tissue if wounds are not present.

SYMPTOMS

The first symptom of the disease is the appearance of small purplish spots on the bark. These areas turn reddish brown in color, increase in size, and the bark eventually becomes dry and cracked. The tips left in cutting off the flowers or in pruning back the plants may become infected in much the same way as in the case of the stem canker on out-of-door roses (p. 11). If the stem below the ground is infected, the area of infection becomes soft and rotted, and the bark can be easily sloughed off. The disease very rarely results in the death of the whole plant, but individual stems and twigs become girdled and die. The growth of the plant is seriously retarded, so that it does not respond to the usual procedure for forcing. Therefore, the usefulness of the plant as a producer of roses of commercial value is lost.

CONTROL

Because of the fact that the fungus lives in the soil, control measures differ from those recommended for the ordinary type of canker. Particular care should be taken by rose growers to prevent the spread of the disease from one greenhouse to another by infected cuttings, plants, tools, or soil. Cankers formed on the upper portions of the stems should be pruned out by cutting well back into the healthy tissue. The pruning shears should be thoroughly sterilized by being dipped in the solution of formaldehyde mentioned in the next paragraph. In order to kill the organism in the soil, it is apparent that any control measures, to be efficient, must be applied directly to the soil. This is accomplished by soil sterilization. The most efficient method in this case seems to be the use either of a solution of formaldehyde or of heat by means of steam.

In greenhouses where infected roses have been grown on benches, the plants should be destroyed and the soil should be thoroughly drenched with a solution in the proportion of 1 pint of commercial formalin (40 per cent formaldehyde) to 25 gallons of water, at the rate of 2 gallons to 1 cubic foot of soil. The houses should remain closed for about 48 hours. The soil should then be turned over several times in order that it may dry thoroughly. All tools to be used on this soil should be sterilized with formalin to prevent its reinfection. After the soil has dried out and the odor of formaldehyde has disappeared the benches may be safely refilled with roses. If the plants are potted instead of being placed directly in the benches, the potting soil should be sterilized either by formalin or by steam. This method of sterilization with formalin is not recommended for houses with ground beds, since the solution does not penetrate deeply enough to insure the complete destruction of the fungus.

Soil sterilization by means of steam [18] is accomplished by various methods, and the decision as to which shall be employed usually depends upon the facilities at hand. Perforated steam pipes may be laid about a foot apart and then covered with soil to a depth of a foot or more. The soil may be covered with burlap bags to prevent the escape of steam into the air. It has been found by experiment that a temperature of 122° F. (50° C.) maintained for 10 minutes is sufficient to kill the fungus. Therefore if the steam is allowed to pass through until the soil becomes completely saturated and a soil temperature of 212° F. is reached, the fungus will be killed. This temperature should be maintained for several minutes to insure the complete destruction of the fungus. Thorough sterilization is of great importance. The least particle of unsterilized soil may contain the fungus, and if this escapes the sterilization process an entirely new infection of the whole house may result.

Since the spores of the fungus may easily be carried about by particles of soil on flowerpots or tools, these also should be carefully sterilized. Boiling water, steam, or a solution of formaldehyde may be used for this purpose. If the solution of formaldehyde is used, the tools or pots are thoroughly drenched with the solution and covered for 48 hours. They are then dried and carefully protected from contaminated soil or other tools until used.

GRAFT CANKER [19]

On grafted plants, particularly those in forcing frames, a disease sometimes appears at or near the point of union of stock and scion. In some cases the scion only is affected, but in others both the stock and the scion are attacked.

SYMPTOMS

The presence of a canker or a callus growth at the union of the stock and the scion and the wilting leaves are usually the first symptoms noted. The canker may entirely encircle the stem, the bark becomes cracked, and the wood tissue seems to be rotted and water-soaked. The death of the whole plant then occurs rapidly. Frequently, however, the canker does not encircle the stem but spreads up it on one side. In this case the bark of the affected portion becomes brown and cracked, but the death of the plant does not immediately follow. In fact, the plant may live for several years after being transplanted to the garden, but healthy branches fail to develop on the side bearing the canker, and this results in a one-sided plant which never shows vigorous growth nor bears normal blossoms. If the stock used in the graft is not resistant to the fungus, the canker may spread below the point of graft, and the death of the whole plant results. Infection of healthy plants or of new wood may take place through the cut ends left in pruning. If material for scions is taken from such infected plants, there is every chance for the spread of the infection.

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[18] For detailed information concerning methods of sterilizing soil by steam, see the following publication: BEATTIE, J. H. THE PRODUCTION OF CUCUMBERS IN GREENHOUSES. U. S. Dept. Agr. Farmers' Bul. 1220, 30 p., illus. 1923.

[19] Caused by *Coniothyrium rosarum* Cke. and Hark.

CONTROL

The growing of resistant varieties only is an important factor in the control of the disease. Manetti root stock is reported as resistant. Scion wood which has been found particularly susceptible includes the varieties Mrs. Charles Russell and Milady. Other varieties may be susceptible, although not definitely reported. Particular care should be taken to cut scion wood from disease-free plants only. In buying grafted plants rose growers should try to obtain only those with Manetti or other disease-resistant stock and with disease-free scion wood. On plants once infected the disease can not be controlled. The only measure to adopt is the destruction by burning of all infected plants.

CROWN GALL [20]

The disease known as crown gall sometimes occurs on nursery or greenhouse roses. It affects also many other cultivated and wild plants, including peach, almond, raspberry, apple, and pear. The disease may be produced on some one of these susceptible plants, such as peach or apple, and the causal organism may then be carried in soil, on pruning shears, or by some other means to a rose plant in the nursery or the home garden, where it may cause infection.

SYMPTOMS

The galls characteristic of the disease occur usually at or near the ground level, but may sometimes be found on the upper portion of the stem or on the roots. Beginning as small swellings, they increase slowly and may attain great size before any effect on the growth of the plant is noticeable. Galls produced on rapidly growing plants are commonly larger than those on more slowly growing ones. Infected plants eventually become stunted in growth, or at least fail to develop foliage and blossoms of good quality. The disease frequently develops so slowly that its injurious effect entirely escapes detection until the plant finally dies. However, cases have been observed in the greenhouse in which the spread of the disease through the plant tissue of infected rose cuttings was so rapid that the plants were entirely destroyed during the first producing season.

The organism causing the disease is a very small bacterium which infects the plants through wounds and lives parasitically within the tissue of the plant. The cells composing the plant tissue are not killed by the organism, but are stimulated by it to abnormal multiplication resulting in the formation of the galls. The bacterium lives over winter in the diseased tissue; thus its development may easily be continued from year to year.

CONTROL

Infected nursery stock is the most common means by which the disease is spread; therefore in buying new plants particular care should be taken to procure disease-free stock, especially if the plants are grafted. Infection takes place only through wounds. For this reason the point of union of stock and scion is particularly favorable

[20] Caused by *Bacterium tumefaciens* Sm. and Townsend.

for infection. Grafts should be carefully wrapped and protected from injury until the union of stock and scion has healed perfectly, leaving no wound where infection might take place.

A plant once infected can not be cured. All infected plants should be removed from the garden or greenhouse and burned. Since the organism is capable of living in the soil for a year or two, roses or other susceptible plants should not be used in infected ground for at least that length of time. If greenhouse soil has become infected it may be sterilized by the methods recommended under the discussion of the control of crown canker. In case such treatment is impracticable, the soil may be replaced by a fresh supply supposed to be free from the disease organism.

The disease may be carried from infected to healthy plants on pruning shears. Therefore all knives and shears used on diseased material should be thoroughly sterilized immediately after using by dipping in a solution of formaldehyde made in the proportions of 1 ounce of formaldehyde to 2 gallons of water. No cuttings should be made from diseased plants, since the organism may be living within the portion used.

BLOSSOM BLIGHT [21]

One of the less common diseases is that called blossom blight. Very little is known as yet regarding its prevalence. It seems to affect only the undeveloped buds or half-opened blossoms.

SYMPTOMS

The characteristic symptom of the disease is the drooping of the flower buds and their failure to open. Upon examination it is found that the interior of the affected buds is filled with a cobwebby mold. There sometimes occurs also just below the flower head a smooth, slightly sunken, grayish black lesion extending down the stem. The buds appear blasted and frequently lop over at or near the lesion.

It has been found in some cases that infection of the blossoms by the fungus causing the brown canker previously described (p. 13) precedes the appearance of this blossom blight.

CONTROL

All infected blossoms should be cut and destroyed by burning as soon as they appear blasted or droop. As previously mentioned, sprays are of little value so far as the control of diseases on the buds is concerned. In order to destroy the lesions and to prevent further infection by the spores of the fungus, the stems adjoining the affected buds should be cut back some few inches below the bud. The remainder of the plant may then be sprayed with ammoniacal copper carbonate (p. 14).

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[21] Caused by a species of Botrytis.